RADIOLOGICAL EVENT REFERENCE GUIDE FOR EMERGENCY RESPONDERS AND HEALTHCARE PROVIDERS

Virginia Department of Health
Emergency Preparedness & Response Programs

VDH VIRGINIA DEPARTMENT OF HEALTH
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RADIOLOGICAL EVENT RELATED ILLNESSES

Radiological accidents or attacks require rapid assessment and treatment of casualties. This guide provides basic information on how to manage radiologically contaminated patients and/or patients who receive a large dose of radiation from an external radiation source. This guide is directed at those who would provide initial medical management to radiological incidents, including acts of terrorism, such as first responders, Emergency Medical Services (EMS), firefighters and healthcare practitioners.

Any unusual symptoms, illnesses or clusters should be reported immediately to the local health department.

RADIATION EXPOSURE AND CONTAMINATION EVENTS

Radiation Exposure: Radiation exposure is received by an individual when a person is near a radiation source. Persons exposed to a radiation source (e.g., when receiving an x-ray) do not become radioactive.

Contamination: Contamination results when loose particles of radioactive material become airborne and then settle on surfaces, skin or clothing. Internal contamination may result if these loose particles are inhaled, ingested, or lodged in an open wound. Since the contamination is radioactive, those who have been introduced to the material need to be decontaminated as quickly as possible.

It is important to understand that individuals can be:

- Exposed to a source, but not contaminated (if no radioactive loose particles or liquids are present);
- Internally contaminated;
- Externally contaminated; or,
- A combination of the above.

1. **Radiation exposure from an external source(s).** This includes exposure to a large radiation source over a short period of time (acute) or exposure to a smaller source over a longer time (chronic). Symptoms depend on the amount of exposure received. (See Recognizing Radiation Related Illnesses section)

2. **Internal contamination from inhalation and/or ingestion of radioactive material.** Internal contamination needs to be assessed and treated in a clinical setting. A person who has inhaled and/or ingested radioactive material is also likely to be externally contaminated. Radiation emitted from inside the body, coming from the internalized contaminated material, is not likely to cause an external radiation exposure hazard to others.

3. **External contamination of the body surface and/or clothing.** Patients are not likely to exhibit any symptoms if they are externally contaminated but have not been exposed to a high energy radiation source. A person who is externally contaminated will probably have internal contamination from breathing contaminated dust/dirt/air. In most cases, external skin contamination is not life threatening and can be removed with soap and water. Radioactive material on the surface of the patient is not likely to cause an exposure hazard to healthcare providers (unless highly radioactive), but a contamination hazard does exist.

   External contamination is likely in the case of a radiological dispersal device – a so-called "dirty bomb." In a dirty bomb event, the major hazard to health and safety is the explosion itself and/or injury from shrapnel. However, if a fragment of a high-energy radiation source pierces or becomes lodged on the victim, an external exposure hazard may exist to that individual and the responder/healthcare provider.

4. **Radiation exposure with internal and/or external contamination.** A combination of the above types of events is also possible.

FIELD MANAGEMENT OF RADIOLOGICAL EVENTS

While a high energy radiation source poses a health risk to individuals, a person who has been exposed to radiation (but not contamination) does not in turn pose a risk to others. At an incident scene, hazardous materials (HAZMAT) personnel will make an initial radiological assessment and will issue specific safety precautions to include the use of appropriate Protective Personal Equipment (PPE).

First responders, fire fighters or HAZMAT should perform an initial assessment for the presence of radioactive material. If contamination is suspected or verified, then assume any victims are externally (and probably internally) contaminated. A "Hot Zone" and adjacent “Control Zone” should be set up to limit access to the contaminated area. Responders working in the Hot Zone should limit their time in this area to what is necessary to assist victims. The Incident Commander should position EMS outside of the Hot Zone so that patient triage/treatment can be done safely.

Three essential factors for minimizing external radiation exposure (not contamination) from a radiation source are:

- **TIME** – The less time spent near the radiation source, the lower the exposure.
- **DISTANCE** – The greater the distance from the source, the less the exposure will be.
- **SHIELDING** – Exposure to radiation can be partially blocked by shielding. Traditionally, shielding is made of lead or concrete. However, staying behind vehicles, buildings, or other objects also decreases exposure.

GUIDELINES FOR FIELD MANAGEMENT

1. **Minimize exposure to radiation sources** using time, distance and shielding.
2. **Use PPE appropriate for the event**, as recommended by the Incident Commander or HazMat Officer. This is particularly important if radioactively contaminated material is present. If available, don personal dosimetry.
3. **Use caution to prevent the spread of contamination** from injured victims to emergency personnel. If an airborne contamination hazard **does not** exist, then **STANDARD PRECAUTIONS** should suffice.

4. **Assess and treat life-threatening injuries immediately**. Treatment takes priority over all other activities including decontamination. Do not delay medical attention for victims with life-threatening injuries. Perform routine emergency care during extrication procedures.
5. **Move victims away from the radiation hazard area using proper patient transfer techniques to prevent further injury.** Stay within the controlled zone if contamination is suspected. Victims should be monitored for contamination once they are medically stable.
6. **Cover wounds with sterile dressings.** Priority efforts should be directed to decontamination of open wounds.
7. **Contaminated patients who do not have life-threatening or serious injuries should be decontaminated on site.** Remove the contaminated person's clothing, including shoes and socks, provided removal can be accomplished without causing further injury. Place items in a plastic bag (double bag if possible) and label with person's name and location (incident site) for future analysis and possible use as legal evidence.
8. **Flush eyes with water or sterile saline. Irrigate or wash skin with tepid water and a mild soap.** Do not use irritants or methods that may abrade the skin as this could cause internal contamination.
9. **Move the ambulance cot (if used) to the clean side of the control line and unfold a clean sheet or blanket over it.** Place victim on the covered cot and package for transport by folding the stretcher sheet over and securing the patient (to prevent cross contamination).
10. **Remove protective clothing before leaving the controlled area, or transfer patient across control line for transport by personnel who have not entered the controlled area.**
11. **Notify hospital.** Advise hospital to expect radiological exposed and/or contaminated patients. Provide number of patients expected, medical conditions, any known radiological information and an estimate of arrival time. Ask for any special instructions the hospital may have. You may be directed to an area other than the routine emergency department entrance for contamination control purposes.
12. **Transport to the hospital.** Follow the hospital's radiological protocol upon arrival. Hand off patients in a manner which reduces the likelihood of spreading contamination. Wrap the patient in a second clean sheet for transfer at the hospital.
13. **The ambulance is considered contaminated until proven otherwise or decontaminated.** However, you may be directed to use the same ambulance for additional trips to the same event site prior to being clean-released.
14. **Have yourself surveyed and decontaminated as necessary.**

RECOGNIZING RADIATION-RELATED ILLNESSES

Determining that someone has been exposed to radiation can be difficult in situations other than catastrophic events (nuclear detonations and severe nuclear power plant accidents). Effects of exposure and/or contamination may not appear immediately following exposure - it can take days or weeks to develop symptoms. The following clinical clues suggest a possible radiological event:

- Acute Radiation Syndrome (ARS) is an illness caused by irradiation of most of the body by a high dose of penetrating radiation in a very short period of time (usually a matter of minutes). ARS follows predictable patterns that unfold over several days or weeks after exposure.
- Cutaneous Radiation Syndrome (CRS) is a damaging dose to the skin without symptoms of ARS. This involves inflammation, erythema, itching and dry or moist desquamation (sloughing of the skin). Also, hair follicles may be damaged, causing epilation (hair loss).
- Victims may present individually over a longer period of time after exposure to unknown radiation sources. Specific symptoms of concern, especially following a 2-3 week period with nausea and vomiting, are:
  - Thermal burn-like skin lesions without documented heat exposure
  - A tendency to bleed (nosebleeds, gingival bleeding, bruising)
  - Immunological dysfunction with secondary infections
  - Bone marrow suppression (neutropenia, lymphopenia, and thrombocytopenia)
  - Hair loss
- Symptom clusters as delayed effects after radiation exposure:
  - Headache, fatigue, weakness
  - Partial and full thickness skin damage, hair loss, ulceration
  - Anorexia, nausea, vomiting, diarrhea
  - Reduced levels of white blood cells, bruising, infections

Table 1: Acute Radiation Syndromes

Syndrome	Prodromal Stage	Latent Stage	Manifest Illness Stage	Recovery
Bone Marrow (Hematopoietic)	• Anorexia, nausea and vomiting • Occurs 1 hour - 2 days after exposure • Lasts minutes-days	• Stem cells in bone marrow are dying, though patient may appear and feel well • Lasts 1 - 6 weeks	• Decreased blood cell counts • Anorexia, fever, malaise • Primary cause of death is infection, hemorrhage • Most deaths occur within months of exposure	• Bone marrow cells often repopulate the marrow • Survival rate decreases with increasing dose • Full recovery for most individuals (few weeks-2 years)
Gastrointestinal (GI)	• Anorexia, severe nausea, vomiting, cramps and diarrhea • Occurs within a few hours after exposure • Lasts about 2 days	• Stem cells in bone marrow and cells lining GI tract are dying, though patient may appear and feel well • Lasts less than 1 week	• Malaise, anorexia, severe diarrhea, fever, dehydration • Death from infection, dehydration, electrolyte imbalance • Death within 2 weeks of exposure	• Survival is extremely unlikely with this syndrome
Cardiovascular (CV)/ Central Nervous System (CNS)	• Nervousness; confusion; nausea, vomiting, diarrhea; loss of consciousness; burning sensations of the skin • Occurs within minutes of exposure • Lasts minutes-hours	• Patient may return to partial functionality • May last for hours but often is less	• Watery diarrhea, convulsions, coma • Begins 5-6 hours after exposure • Death within 3 days of exposure	• No recovery

TABLE 2: ACUTE RADIATION SYNDROME CLINICAL EVALUATION TABLE (Whole Body Radiation from External Radiation or Internal Absorption)

Phase	Feature	Subclinical Range		Sublethal Range		Lethal Range	
		0 - 100 Rad	100 – 200 Rad	200 – 600 Rad	600 – 800 Rad	800 – 3000 Rad	> 3000 Rad
Prodromal	Nausea, vomiting	None	5 – 50%	50 – 100%	75 – 100%	90 – 100%	100%
	Time of Onset	N/A	3 – 6 hours	2 – 4 hours	1 – 2 hours	< 1 hour	Minutes
	Duration	N/A	< 24 hours	< 24 hours	< 48 hours	< 48 hours	N/A
	Lymphocyte Count	Unaffected	Minimally decreased	< 1000 at 24 hours	< 500 at 24 hours	Decreases within hours	Decreases within hours
	CNS Function	No impairment	No impairment	Routine task performance; cognitive impairment 6 – 20 hours	Simple and routine task performance; cognitive impairment for > 24 hours	Rapid incapacitation; may have a lucid interval of several hours	
Latent (Subclinical)	Absence of Symptoms	> 2 weeks	7 – 15 days	0 – 7 days	0 – 2 days	None	
Acute Radiation Illness ("Manifest Illness")	Signs and Symptoms	None	Moderate leukopenia	Severe leukopenia, purpura, hemorrhage; pneumonia; hair loss after 300 Rad		Diarrhea, fever, electrolyte disturbance	Convulsions, ataxia, tremor, lethargy
	Time of Onset	N/A	> 2 weeks	2 days – 2 weeks		1 – 3 days	
	Critical Period	N/A	None	4 – 6 weeks: Most potential for effective medical intervention		2 – 14 days	1 – 48 hours
	Organ System	None	N/A	Hematopoietic and respiratory (mucosal) systems		GI tract, mucosal systems	CNS
Hospital	%, Duration	0	< 5%; 45 – 60 days	90%; 60 – 90 days	100%; 90+ days	100%; weeks to months	100%; days to weeks
Mortality	----------	None	Minimal	Low with aggressive therapy	High	Very high; significant neurological symptoms indicate lethal dose	

HOSPITAL MANAGEMENT

PRECAUTIONS

It is important to remember that a person who has been exposed to a radiation source is unlikely to pose a health risk to any other person. However, if a person is suspected or confirmed to have been contaminated, then decontamination is necessary (if not performed at the scene) and internal contamination should also be assumed until proved otherwise.

Use of **Standard Precautions** will help prevent the spread of contamination and should be used in any situation where the presence of radioactive materials is suspected. Healthcare providers should not delay treatment of patients due to fear of becoming contaminated with radioactive material. The patient should be handled in a manner that will reduce the potential spread of contamination to other individuals and medical equipment (e.g., stretcher, ambulance).

DECONTAMINATION GUIDELINES

Whenever possible, decontamination of patients should occur at a location other than the Emergency Department. This scenario, including location, equipment and resources needed to perform decontamination should be pre-planned and practiced.

Request assistance from the Radiological Officer to conduct radiation and contamination surveys and to determine PPE appropriate for the event, including the use of personal dosimetry.

Proper decontamination of patients is important to prevent contamination of facilities and equipment, and to prevent exposure to other individuals. Immediate removal of the patient's clothing, including shoes and socks, can remove up to 90% of the contaminant. Removed clothing, double-bagged and sealed to prevent spread of contamination, should be retained as possible evidence. After clothing is removed, the patient's skin, eyes and/or hair may need to be decontaminated. In most cases, this can be accomplished by gently washing skin and hair with soap and water followed by a thorough water rinse. It is important not to abrade the skin during washing or rinsing, as this can lead to internal radioactive contamination of the patient. For eyes, flush with plenty of water.

TREATMENT AND DECONTAMINATION

Triage:

- Patient with life-threatening condition: treat, then decontaminate.
- Patient with non-life-threatening condition: decontaminate, then treat.
- Treating contaminated patients before decontamination may contaminate equipment, vehicles and the facility. Plan for patient decontamination before entry to Emergency Department if not medically contraindicated.
- For contaminated patients, use **Standard Precautions**; remove patient's clothing (including shoes and socks); decontaminate with soap and water; sequester runoff to the furthest extend possible.
- Externally irradiated patients are not contaminated. Exposure without contamination requires no decontamination.
- Monitor patient for contamination (if condition permits). Continue decontamination and follow-up monitoring until is successful.

Treatment:

- Secure ABCs (airway, breathing, circulation) and physiologic monitoring (blood pressure, blood gases, electrolyte and urine output).
- Treat major trauma, burns and respiratory injury if evident.
- Initiate prevention and treatment of infections.
- Decontaminate wounds with copious irrigation. Sequester effluent.
- Consider available medical countermeasures (e.g., Potassium iodide, Insoluble Prussian Blue, Bicarbonate ($NaHCO_3$), etc.)

Monitoring/Testing:

- In addition to the blood samples required to address trauma, obtain samples for CBC (complete blood count), with attention to lymphocyte count, and HLA (human leukocyte antigen) typing. Roughly:
  - Absolute lymphocyte count <1000 mm^3 = moderate exposure
  - Absolute lymphocyte count <500 mm^3 = severe exposure
- If exposure occurred within 8 - 12 hours, repeat CBC for lymphocyte count every 2 - 3 hours for the first 8 - 12 hours following exposure, and then every 4 - 6 hours for the following 2 - 3 days to assess lymphocyte depletion. This provides an estimate of the dose received. If possible, have radiation dosimetrists conduct the dose assessment.
- Consider a pregnancy test for women of reproductive age – radiation effects on the developing fetus require special consideration.
- Nasal swabs to evaluate internal contamination (nasal swab activity represents ~5% of lung deposition).

- Collect vomitus in the first few days for later analysis.
- Collect 24 hour stool if GI contamination is possible.
- Collect 24 hour urine if internal contamination is possible.
- Monitor for clinical symptoms, particularly nausea, vomiting, diarrhea, itching, reddening or blistering of the skin, hair loss, skin injury, mucositis, parotitis, weight loss, or fever. If possible, take color photographs of suspected radiation skin damage.
- Consider tissue, blood typing, and initiating anti-viral prophylaxis.
- Provide psychological support.
- Consult with radiation, hematology and radiotherapy experts on dosimetry, prognosis and treatment options, and emergency management personnel on monitoring, sampling and disposal.

POTASSIUM IODIDE (KI)

In the event of a severe nuclear power plant accident, health officials may direct the use of potassium iodide (KI) tablets in addition to evacuation and sheltering. KI protects the thyroid by saturating it with non-radioactive iodine, thereby minimizing the uptake of radioactive iodine. It must be taken within the first few hours after exposure to be effective. Persons allergic to iodine or shellfish should not take KI.

KI is only effective for protecting the thyroid gland from radioiodine exposure (e.g., from a nuclear power plant event). It is not typically an effective treatment for "Dirty Bombs" since radioiodine is not usually associated with that type of event. KI does not protect against radiation illness. It is given to decrease the long term risk of developing thyroid cancer.

TABLE 2: POTASSIUM IODIDE DOSAGES

Age Group	Dosage
Infants < 1 month	16 mg (1/8 of 130mg tablet)
Children 1 month – <3 years	32 mg (1/4 of 130mg tablet)
Children 3 – 18 years*	65 mg (1/2 of 130 tablet)
Adults	130 mg (1 tablet)

* Adolescents approaching adult size (70 kg or 150 lbs) should receive the full adult dose (130 mg).

Note: Partial tablet doses can be prepared by dissolving one 130 mg tablet in 4 tsp. water and measuring accordingly (i.e., 1 tsp = 32 mg KI). PIMA® cough syrup is also available by prescription, as well as saturated solution of potassium iodide (SSKI) and Lugol's solution.

REPORTING

If there is a reasonable suspicion of a radiological event, contact:

- Hospital Radiation Safety Officer - Obtain monitoring assistance and guidance on PPE, dosimetry and decontamination
- Hospital leadership - Immediately discuss hospital emergency planning implications.
- Local emergency management and public health offices.
- Virginia Department of Emergency Management, through the Virginia Emergency Operations Center (VEOC) at (800) 468-8892 or (804) 674-2400.

REFERENCES AND RESOURCES

- Virginia Department of Health
  www.vdh.virginia.gov/EPR/Agents_Radiation.asp
- Radiation Emergency Assistance Center/Training Site (REAC/TS)
  www.orau.gov/reacts/guidance.htm
- Armed Forces Radiobiology Research Institute
  www.afrri.usuhs.mil/
- Management of Terrorist Events Involving Radioactive Materials. National Council on Radiation Protection. NCRP Report No. 138 (2001).
- Centers for Disease Contrlo
  www.bt.cdc.gov
- Department of Homeland Security, Working Group on Radiological Dispersal Device (RDD) Preparedness
  www.appc1.va.gov/emshg/docs/Radiologic_Medical_Countermeasures_051403.pdf

DISCLAIMER

The information contained in this document is intended to be a guide, and is not comprehensive. This information, or the web sites and references listed herein, are not a substitute for professional medical advice, diagnosis, or treatment. Please consult other references and expert opinion, and check dosages, particularly for children and pregnant women.